

Engineering Aspects of War

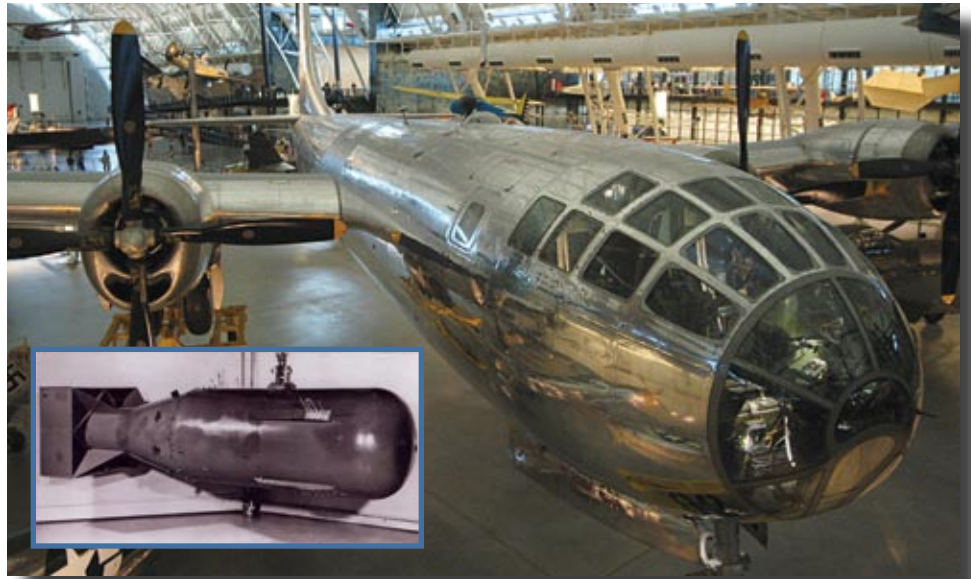
Part III

by Dr. Arthur D. Delagrangé, *Massachusetts Beta '62*

A ship carrying a special cargo made its way across the sea toward the “home islands” of Japan. A group of boxes bearing dire warnings was continuously guarded by sentries. There was nothing of value in them, but a short distance away was an unmarked box containing the first nuclear device to be used in combat.

On August 6, 1945, the bomb killed 60,000 people at Hiroshima, with an equal number to die later. This was fewer than had been killed in some firebombing raids, but this was with a single bomb. A few days later, another was dropped, of a different design, as we weren't positive either would work as expected. Now convinced that it had indeed been hit with nuclear devices and not knowing how many more we had (none), Japan capitulated.

As chemical weapons (gunpowder) had upped the available energy density by orders of magnitude, unlocking the



Enola Gay, the B-29 that dropped the Hiroshima bomb, “Little Boy,” inset, at Udvar-Hazy Museum, Dulles Airport, VA. Main photo: the author.

atom had now taken it to a new level. Hiroshima became a household word, the giant mushroom cloud became a symbol, and the nuclear age was born.

The Manhattan Project

A number of scientists were aware of the implications of splitting the atom, but the principals seem to be these: Heisenberg in Germany told Hitler he believed that a chain-reaction bomb was possible, but that Germany could not obtain enough enriched uranium. (He later claimed that the latter was a purposeful lie.)

In the U.S., Leo Szilard, Enrico Fermi, and Edward Teller discussed the possibility with Albert Einstein, convincing the famous pacifist to take the idea to President Roosevelt. “FDR” ordered the “Manhattan Project,” said to be the largest project ever undertaken. Somehow secrecy was maintained with respect to Germany and Japan. It was porous with respect to the Soviet Union: Joseph Stalin knew we had the bomb before President Truman.

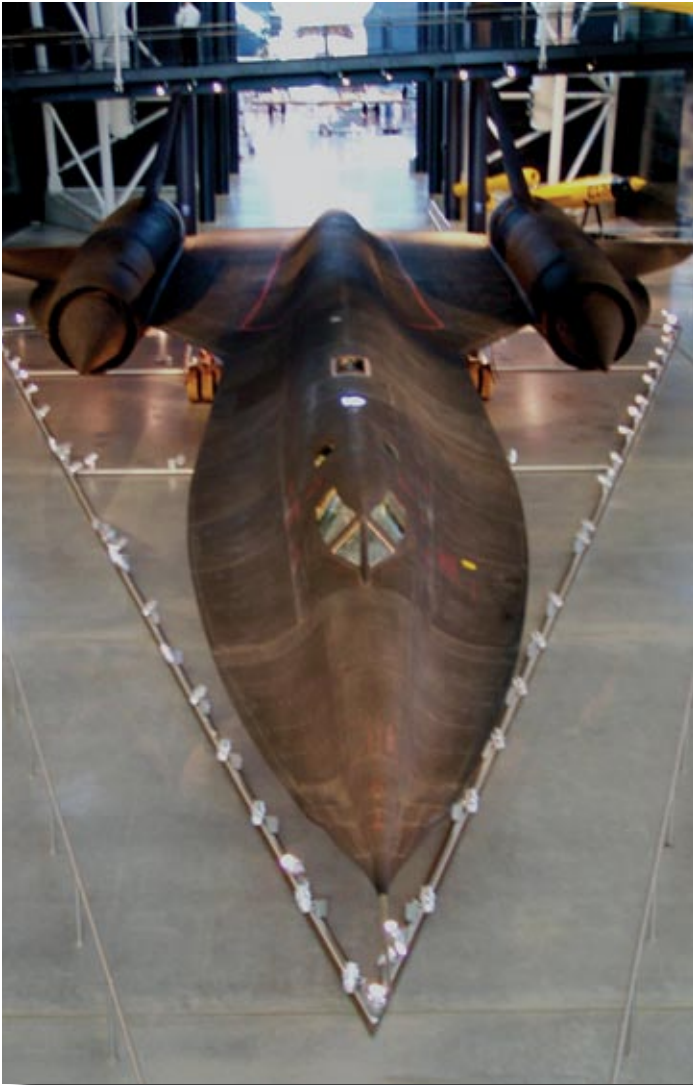
Faced with the possibility of a million U.S. dead to invade Japan proper and an equal number on their side, Truman gave the go-ahead to use the bomb.

The Cold War

The Cold War, also known as WWII or the War that Was Never Fought, was our longest—half a century—and the most scientifically intensive. It was fought from the laboratories; I was a part of it. The U.S. viewed WWII as the end of war; the Soviet Union was more far-sighted and viewed it as only the beginning. Each side jockeyed for a position of overwhelming superiority that would force the other to surrender without a fight. Eventually the Soviets' bureaucracy, which self-destructed to the point of deposing or even executing its own leaders, and its unworkable centrally-planned economy, fell to our capitalist system, the object of their scorn.

In the meantime, both sides tested their weapons in surrogate wars such as Korea and Vietnam, continuously building on the technology from the end of WWII. An exception was nuclear weapons: the fission (uranium) bomb was supplemented by the fusion (hydrogen) bomb, but these fortunately were never used in combat.

The jet quickly took over in the air and soon became supersonic, although most operations were still conducted subsonic. Performance was such that the pilots had to wear special suits to survive the g-forces. The payload of



A Blackbird spy plane at Udvar-Hazy Museum, Dulles Airport, VA. The type was in use for 30-plus years, setting speed and altitude records of Mach 3.2 and 85,000 feet. Photo: the author

bombers became unbelievable: a bomb load (conventional) large enough to rearrange a small country or to transport not only armies of men but their trucks and even tanks. The helicopter came of age, first for observation, then rescue, and then for transport or as a viable fighting platform on its own. Fixed-wing aircraft with VTOL (vertical takeoff and landing) capability were developed, but have seen limited use.

Guns gave way to rockets: no recoil, bigger payload, and autonomous (target-seeking). Big rockets grew into the ICBM (inter-continental ballistic missile), reaching the far side of the globe. Internal inertial guidance was the key here; nearly impossible to decoy, jam, or even intercept, these nuclear-tipped rockets kept entire nations in fear from afar.

At sea the big item was the submarine, now nuclear powered. Subs no longer had any semblance of a deck. Their habitat was strictly the three-dimensional world below; they were *flown* much like airplanes. There was a constant

contest between better detection gear, and quieter, deeper, and faster subs. In some areas they could simply disappear; you simply knew they were out there somewhere, carrying nuclear missiles. One of ours repeated Magellan's feat of circumnavigating the globe, except this time completely under the surface. A special class of sub was developed to hunt other subs. Torpedos now had their own sonar, or else were guided by wire from the mother ship.

On land, in spite of all the technology, the foot soldier remained the basic fighting tool. But he was better equipped, better fed, better supported, delivered faster, rescued more often, and treated better.

Korea

The Korean War was not significantly different technologically, but it was so politically. It was termed a *police action*, not a war. It was the start of *surrogate* wars—theoretically between two small countries but in actuality a testing ground for the superpowers. South Korea was supposedly aided by the United Nations, which in reality was mostly the U.S. The *peace* at the end left the border exactly where it started and an uneasy truce. President Harry Truman's firing of General Douglas MacArthur determined that wars would hence be directed from the White House, not the Pentagon.

Vietnam

In Vietnam, we attempted to bring war to a new level of sophistication, working on remote sensors to detect the enemy. We hoped that he could be interdicted while avoiding the civilians, a first attempt at *surgical* warfare. The opposition adopted crude guerrilla warfare, hiding among and indistinguishable from the civilians, and, with the notable exception of foreign-made SAMs (surface-to-air missiles) that were quite effective, used low technology, easily replaceable weapons. We could turn a dirt road into

A War that Started by Mistake

Two U.S. warships off the coast of Vietnam were allegedly fired upon. A stern warning was sent to North Vietnam. Then a second attack was reported, with radar and sonar contacts and explosions. However, no enemy craft was sighted, and the ships sustained no hits.

The data was given to an analyst to determine whether there actually had been an attack. He was unable to say; more data was needed. An order came back from President Johnson saying there would be no more data and he wanted a "yes" or a "no," as he planned to go to Congress the next day. The analyst said, well, if trained observers reported an attack, he could not contradict them.

The "Gulf of Tonkin" resolution was passed, and we became embroiled in a bitter, costly, and dubious war. When more data did arrive, it became clear that storms in the area had caused a false alarm.

Tricks of the Code Trade

A Japanese message discussing a planned attack on "MI" was intercepted. This probably meant Midway Island, but if it meant something different we would be sending scarce resources to the wrong place. Headquarters sent Midway a coded instruction to send back an uncoded message saying they were low on drinking water. Sure enough, a subsequent Japanese message contained the "good news" that the targeted MI was low on drinking water.

a series of mammoth craters, but the next day there would be a new road nearby.

Low-technology won. Ultimately the war was fought mostly by foot soldiers, and casualties were high, the exact opposite of what was predicted. Politics was involved more than technology, and eventually we left.

Communications and cryptology

A major *improvement* in warfare had come with the introduction of radio. Central command, now in instantaneous communication with the field commanders, could change plans on the fly. Likewise, the field commanders were in communication with their troops via portable radios.

The frequencies feasible in the '40s were too low to allow highly directional antennas, so the enemy was listening, too. Messages had to be encoded, and code-breaking became crucial. The Germans had the most sophisticated equipment (the "Enigma" machine), but we captured one, and between slips on their part and a tremendous effort by British and Polish teams (no computers yet) we kept pretty well informed. In the Pacific the Japanese were less sophisticated, and several times we captured a current code book, and through round-the-clock work by teams in Hawaii we generally knew their planned moves. We intercepted and downed the plane of Yamamoto, Japan's admiral of the fleet, using information from a decoded message.

Near the end of WWI the Choctaw Indians used their native language with no code at all; the war concluded before the Germans understood it. In WWII, the Navaho Indians devised a code simple enough to be committed to memory. This, used in conjunction with their native language, which was complicated to start with and had to use arbitrary words for modern devices like *airplane*, was never broken by the Japanese. These *wind-talkers* always had an escort whose assignment was to protect them if possible, but it was known by both that a secondary assignment was to shoot them if not.

The measure of usefulness of a code is whether the enemy can break it in time. Modern computers can break the old codes in a short time, but they in turn can generate codes so complicated that it takes even a computer an unacceptably long time to break.

Reconnaissance, spying, and espionage

In a study of past battles, almost invariably it is evident that



German soldiers use an Enigma code machine on the Russian Front, 1943-44. Photo: Bundesarchiv

Information too Good to be Used

After WWII, Berlin was partitioned between the U.S., Britain, France, and the Soviet Union. Naturally each maintained a strong spy presence. The Brits tunneled under the Berlin Wall and tapped into a main Soviet telephone line. The information obtained was so revealing that much of it could not be used, as it would alert the Soviets that their communication had been compromised.

Even more astounding, the Soviets knew it! They had a spy placed high in the British Government, so high that any drop in usage of the line would tell the Brits that one of the half-dozen men that knew of the operation was a spy. The Soviets took no action, not even alerting the users of the line, for fear any apparent cautiousness would give their secret away!

Chess—the Game of War

The game of chess was designed to simulate war. Although the KING is basically a figurehead with little capability, inability to protect it means loss of game. The QUEEN, who starts beside the king, is actually the most powerful piece, and can move much faster. BISHOPS, KNIGHTS, and CASTLES have their distinct capabilities and limitations. PAWNS are mostly sacrificed, although, if one is not blocked or captured and moves all the way behind enemy lines, it can release a prisoner (exchange for a captured piece). Note that chess is considered *the* premier game; also note that it takes a powerful computer/program to beat a human master.

one or both sides had insufficient knowledge of its opponent. (In some cases commanders did not even seek information.) In probably the majority of cases, the battle could have gone the other way if the loser had complete knowledge of the enemy's plans. A survey of modern warfare would seem to indicate that we still haven't learned. The loss of a few more spies or spy planes would have been small compared to some of the military disasters due to unpreparedness.

The differences between reconnaissance, spying, and espionage are slight, but could be exemplified by saying that reconnaissance is done by uniformed troops, spying by non-uniformed, and espionage by apparently friendly persons. The first probably reached its zenith during the Civil War when the populace anywhere near the front lines would be accustomed to seeing a small party of enemy troops riding by and gathering information, often behind (or even through!) the troop camp. The old Soviet Union was the acknowledged master of the other two. They exploded the first H-bomb largely on our plans. They flew the first SST (super-sonic transport), which was so similar to the British-French plane under development that it was dubbed the "Concordski." Reportedly, the best map of Westchester County, NY, was available from the Soviets. Most Soviet citizens in the U.S., no matter what their reason for admission, were trained in spying and/or espionage. They were discouragingly successful at recruiting informational sources for a tiny fraction of what it would have cost them to do the work themselves.

Tactics

Tactics is finding the best use of available resources (engineering) while denying the same to the opposition (negative engineering?). Many rely on surprise; better yet if they do not. Some are simple and obvious: Fight when you have the advantage; hide when you don't. Figure out what the enemy wants you to do, and then do something different. Entire books have been written on tactics.

Many involve maneuvering so that a large part of your forces engage a small part of the opposition for a sure victory, but this can backfire. The Alamo was a sure loss of some good men, but it delayed the Mexicans long enough

to leave them at an overall disadvantage. A related tactic is the Pyrrhic (after a commander who outsmarted the Roman army) victory: making sure your defeats are so costly to the enemy that he cannot afford to keep fighting, even though he is winning the battles.

Many of the more famous tactics have been alluded to here: The ancient Greeks developed the phalanx, a shoulder-to-shoulder line of soldiers with their rectangular shields touching, a virtual moving wall with only their helmeted heads and booted feet (and spear tips) showing, with a line of replacements behind in case one did fall. It was virtually unstoppable by a defense not similarly organized—until the advent of mounted cavalry, which could encircle it faster than it could move. A similar tactic was outlawed in football, possibly the nearest civilian equivalent.

Psychological warfare

As psychology is among the least exact of the sciences, psychological warfare is probably the least predictable form. A particularly brutal attack may discourage the opponent, or it may steel his determination. Pearl Harbor disabled a third of our Pacific Fleet, but, in the words of a Japanese commander, "awakened a sleeping giant." On the other hand, the A-bomb did break the will of the Japanese.

More than one battle has been won by a dummy (or imagined!) weapon that was, in fact, impotent (or never existed). During the Civil War, the Yankees built a huge "gunboat" to protect their fleet. In reality, it was an old barge with fake armor plating; its "guns" were telegraph poles. The rebel ships declined to engage this awesome threat, keeping them out of action until it was too late.

Being convinced that you are going to win may cause fatal carelessness, or sheer bravado may carry the day. However, a belief that you are going to lose is usually self-fulfilling. Best bet: stick to the available facts.

The Gulf War

This article purposefully stops short of the Gulf War, because the readers should be able to recall it. The major weapons and tactics were covered *ad nauseam* by the press, and it is virtually impossible to hide the use of a new weapon. But as far as details, it is best to disregard the early press reports. It is hard enough for the military to determine accurately what is happening, and there is little incentive to make that information available to the enemy.

The Rules of War

Much has been said about the *rules of war*. Actually, there are few, because war occurs when somebody refuses to abide by the rules of civilization. The laws of physics and economics still apply, no matter how noble your cause. Anything you do to your opponent may be copied and done to you in return. There are no referees and no time-outs. In a true war there are no civilians; whoever is not on your side is a liability. Lastly, the winner gets to write the history books.

The war on terrorism

More properly, the war on terrorists is already being termed WWIV. It is guerrilla warfare with a new twist: the guerrillas are among us, even more so if we talk in terms of a *world community*. The hope seems to be that modern technology can save us. This strategy failed in Vietnam. In theory, if we can gather all the information in the world, coming attacks can be spotted. Given that we didn't use the information we had before 9/11, I don't have high hopes.

The Hegelian concept that, because organizations theoretically have the sum total of the brainpower of the individuals, government is the smartest entity seems to have gone terribly awry. Stories of airline-security non-sense could fill a book, but my favorite concerns the Army soldier who was required to go through screening like everyone else. His nail clippers were confiscated, but he could keep his M-16. However ridiculous, I'm sure this is exactly what the regulations specified.

The future

War is becoming disturbingly like the science-fiction movies of my youth: death rays (lasers), spaceships (space shuttle), space weapons (killer satellites), robot warriors (autonomous weapons), energy fields (electro-magnetic pulse from nuclear explosions), and thought control (may be classified).

The trend (for us) is clearly technology: *smart bombs* and *designer* weapons to pick out the bad guys or items but that avoid *collateral damage*. Better detection systems are a high priority: for explosives, hidden weapons, and personnel location (and identity and even motivation). However, with personal computers, GPS, and cell phones, terrorists have capabilities exceeding those of the military in WWII. The question is whether we can "out-tech" them.

Here is my prediction, based on history: the war on terrorism will be hamstrung by politics, opportunism, sentimentality, and resistance to reason until something really bad happens. When the terrorists do indeed have weapons of mass destruction, there could be a blow to civilization that will make WWII pale in comparison.

Conclusion

In 37 years as an engineer with the Department of Defense, I never met anyone who wanted war. But there was a single-mindedness of purpose; if war did come, we had better be prepared to fight it, on whatever terms the enemy dictated, and win. Working with weapons daily we knew that war was horrible, but we believed that surrender was unthinkable. I believe that my work in engineering did make the world a better place.

References

1. The Bible
2. *Biblical Archaeology Review*, various issues
3. *Military History Quarterly*, various issues
4. *Technology Review*, various issues
5. *The Legacy of the White Oak Laboratory*, U.S. Department of the Navy
6. "The Civil War" series, *The Washington Times*
7. *Technology and War*, Martin Van Creveld



A New York City firefighter looks up at what remains of the World Trade Center two days after its collapse during the September 11, 2001, terrorist attack. U.S. Navy Photo by Photographer's Mate 2nd Class Jim Watson.

Acknowledgement: The author thanks Ms. Betty Gay and Capt. William Gay, USN (ret.), for their suggestions.

Arthur D. Delagrang, *Massachusetts Beta '62*, received a B.S. and M.S. from the Massachusetts Institute of Technology in 1962 and a Ph.D. from the University of Maryland in 1974, all in electrical engineering. He worked at the Naval Surface Warfare Center (now closed) in Silver Spring, MD, during 1959-94. Holder of nine patents, Art has authored 68 governmental reports, 22 articles in trade magazines, and a chapter in *The Art and Science of Analog Design*, edited by Jim Williams (Butterworth-Heinemann). He has written articles for *THE BENT* on the C&O Canal (Fall 1999), B&O Railroad (Spring 2000), automobiles (Spring and Fall 2001), race cars (Winter 2008), power boats (Summer 2002), and music (Winter 2003) [see www.tbp.org]. Since retiring, Art has done consulting both as a free lance and for Advanced Research and Technology, Burtonsville, MD. He and his wife Janice live near Mt. Airy, MD.